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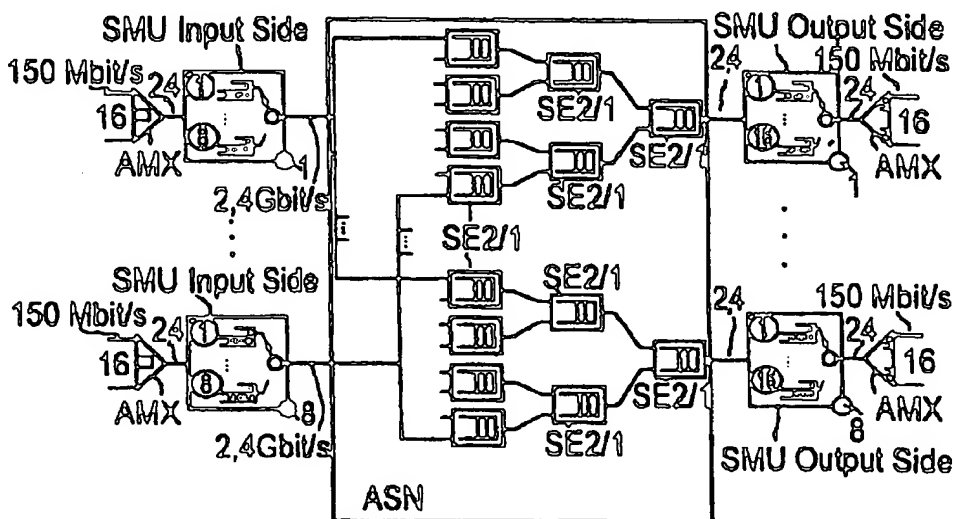
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(54) ATM communication system for statistical multiplexing of cells

(57) The ATM communication system comprises a plurality of upstream interfaces (SMU), at least one multi-stage funnel of switching elements (SE) connected thereto and at least one downstream interface (SMU), whereby each of the switching elements comprises a plurality of inputs and at least one output to which a logical queue is associated. The logical queue of each of the switching elements (SE) is common for different traffic classes. For the filling of the logical queues to each of the traffic classes a predetermined threshold is

defined. In case of exceeding the threshold for the respective traffic class by receiving a message cell for this traffic class a back pressure signal is transmitted only to the switching element or upstream interface, respectively, just transmitting this message cell. The transmission of message cells is stopped by this switching element (SE) or upstream interface (SMU), respectively, for a predetermined period of time periodically until resetting the back pressure signal.

FIG 2



Description

The present invention relates to an ATM-communication system for statistical multiplexing of message cells according to the preamble of claim 1.

A general system architecture for an ATM Concentrator/Switch-in the following designated as system- is based on the use of large buffers (for example several megabytes) as illustrated in figure 1. These architecture includes ATM Multiplexers (AMX), Statistical Multiplexing Units (SMUs) with large input and output buffers and a high speed ATM Switching Network (ASN).

The AMXes are responsible for concentrating a group of input lines onto a higher speed trunk and conversely distributing cells from a high speed output trunk to a number of outgoing lines. The SMU on the input side (upstream SMU) contains a large shared memory buffer which is split into separate logical queues, one for each SMU on the output side. The ASN switches cells to the correct high speed ASN port which is attached to an output side SMU. The output side SMU (downstream SMU) has a large shared buffer which can be divided into a number of logical queues (one per output port of the AMX). These queues will ensure that the outgoing line is not overloaded. More complicated functionality may also be added to provide an egress traffic shaping capability on a per VCC basis.

A system with large buffers allows high level of statistical multiplexing gain for bursty traffic with moderate delay requirements (not real time) and high peak bit rates. Burst level congestion is effectively avoided by buffering the bursts and fairly sharing the available bandwidth between active connections.

It is an object of the present invention to provide an ATM communication system for statistical multiplexing of message cells with avoiding message cell losses.

This object is solved with the features of claim 1. This ATM communication system uses stop/go signals for transmission of message cells based on thresholds in the queues of switching elements (SEs) located in at least one funnel of switching elements. When the contents of a queue in the switching elements exceeds a predefined threshold a "receive not ready" signal is set and sent to the unit which had sent a cell being buffered behind the threshold of the respective queue and traffic class.

The sending queue stops the transmission for a time-out period and then the server can start again. This operation with a suitable length for the time-out period ensures that no cell will be lost in the ATM communication system.

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description taken with the accompanying drawings, in which

Fig. 1 shows a general system architecture for an ATM communication system in which the present invention is used,

Fig. 2 shows an embodiment for an ATM communication system,

Fig. 3 shows the queuing concept for the switching elements of a ATM switching network shown in Figures 1 to 2 and

Fig. 4 shows the cabling for the queuing concept in the ATM communication system of Fig. 2

The general system architecture for an ATM communication system was described before. In this ATM communication system the logical input queues in the upstream statistical multiplex units SMU have subqueues for each traffic class and are served in a modified Round Robin Strategy which takes care of the time priorities of cells of the different traffic classes. This means that cells of non real time traffic are only transmitted from the statistical multiplex units SMU to the switching network ASN if no cell of real time traffic is waiting in the upstream statistical multiplex units SMU.

The logical output queues in the downstream statistical multiplex units SMU have subqueues for each traffic class and the subqueues are served with time priority for the cells of the real time traffic.

In the following the system of Fig. 2 is considered. For example this system may be designed for transmitting message cells of virtual connections with a bit rate up to 2,4 Gbit/s. These virtual connections are associated to different traffic classes. The ATM switching network ASN of this system is a multistage network and comprises in the different stages switching elements SE which have in each case one common queue for real time and non real time traffic. There are no delay priorities. All switching elements have a shared buffer which is organised using output queueing. In the following the output queue for one output interface of a switching element SE or a statistical multiplex unit SMU is denoted as logical queue.

The 2.4 Gbit/s system of Fig. 2 has 128 input / output trunks with 150 Mbit/s connected at upstream / downstream ATM multiplexer AMX. There are eight up- and downstream statistical multiplex units SMU connected in each case to one of the multiplexers and working on a data rate of 2.4 Gbit/s. The traffic of an upstream multiplexer AMX is transmitted to the upstream statistical multiplex units SMU with eight logical queues. The switching network ASN has a three stage funnel structure built out of switching elements in the form 2|1. Each downstream statistical multiplex unit SMU has 16 logical queues one for each 150 Mbit/s link of the following downstream multiplexer AMX.

The switching elements SE for the 2.4 Gbit/s system of Fig. 2 have in each case two input interfaces and one output interface and one logical output queue. Each of the logical queues of the switching elements is served by one 2.4 Gbit/s link. Such a logical queue is a common queue for all delay classes for example real time traffic and non real time traffic and overtaking of cells from different delay classes is not possible within the switching elements.

The aim of the back pressure mechanism of the present invention is to protect the short queues in the switching elements SE of the switching network ASN against cell loss. Back pressure means that a switching element SE sends a "receive not ready" signal when the content of its queue exceeds a predefined threshold T (specifying the congested queue) to the switching element SE or statistical multiplex unit SMU which had directly sent a cell to the congested logical queue for a time-out period. The switching element SE or statistical multiplex unit SMU which receives the signal will stop sending cells to the congested logical queue. The statistical multiplex units may continue to send cells to other not congested queues.

Due to the funnel structure of the switching network ASN and the specific queueing (one separate queue for each downstream statistical multiplex unit SMU) in the upstream statistical multiplex units SMU all cells which are waiting in the same logical queue of a statistical multiplex unit SMU or of a switching unit SE are destined to the same logical queue in the next stage of the system. Therefore head of line blocking by using a back pressure mechanism is avoided.

For the back pressure mechanism there are thresholds T for the queue of a switching element SE which can be adjusted individually for each traffic class. At the present embodiment two thresholds are defined, T_N for the non-real time traffic and T_R for the real time traffic with $T_N < T_R$. When an incoming cell has to be buffered and the threshold for the traffic class to which this cell belongs is exceeded, then the cell will be buffered, but via a back pressure signal "receive not ready" only the queue sending this cell is informed. Then only this sending queue stops the transmission of cells for a predefined number of cell cycles by means of a time-out counter. All other queues continue the transmission of cells until they get an individual "receive not ready" signal. This queueing concept is depicted in Fig. 3.

For each queue in the switching elements SE the number of boolean back pressure signals needed for sending corresponds to the number of switching elements SE or upstream statistical multiplex units SMU which send directly cells to the queue. This back pressure signals are transmitted back to the switching elements SE or to the upstream statistical multiplex units SMU which send directly cells to that queue. For each queue in the switching elements SE and in the upstream statistical multiplex unit SMU, one boolean signal for receiving the back pressure signal is needed.

For each queue in the switching elements SE and in the upstream statistical multiplex units SMU, the length of the time-out periode can be adjusted individually (in number of cell cycles) by means of the time-out counter belonging thereto. When a queue of one of the switching elements SE or the statistical multiplex units SMU receives a back pressure signal "receive not ready" from the subsequent switching element SE, the respective queue stops the transmission of all cells for the adjusted number of cell cycles. In the time-out period of a queue

in the statistical multiplex unit SMU, the statistical multiplex unit SMU can transmit cells from other queues belonging thereto which have not stopped for the transmission.

The time-out counter for the queues in the SEs is determined such that no more cells will enter the congested queue in the subsequent switching element SE than will leave the congested queue in the subsequent switching element SE within the time-out periode. To determine the length of a time-out periode for a queue, the queue has to assume that all other queues which are sending cells to the same congested queue will send a cell in each cell cycle. Therefore each queue has to stop the transmission for so much cell cycles as there are other queues in the ASN funnel sending to the same congested queue in the last switching element SE of the ASN funnel. For the queues in the switching elements SE of the last stage in the switching network ASN this means that the time-out periode is zero, because there is no back pressure from the downstream statistical multiplex unit SMU back to the switching network ASN.

There is no cell loss in the switching network ASN for all traffic classes if the thresholds for the traffic class with highest priority (here T_R) in the queues of the SEs is chosen as the difference between the value of the queue capacity and the number of queues sending to the queue. The queueing delay of real time traffic cells will not increase too much if only a few cells of non real time traffic will be buffered in the queues of the switching elements SE. This could be ensured by choosing a very low threshold T_N for non real time traffic in all queues of the switching elements SE. But there is a lower bound for the threshold T_N so that the queue will not run empty after the reset of the back pressure signal.

In the following the cabling concept shown in Fig. 4 for the transmission of the back pressure signals in the system according to Fig. 2 is considered.

In each switching element SE with the structure 2|1, there have to be one input and two outputs for the back pressure signals. Since there is a one to one relation between the logical queues in the statistical multiplex units SMU and the input interfaces of the switching elements SE in the first stage of the switching network ASN it is possible to transmit the back pressure signals directly to the upstream statistical multiplex units SMU. Each statistical multiplex unit SMU needs eight inputs for receiving back pressure signals. In Fig. 4 only two of the eight upstream statistical multiplex units SMU and funnels in the switching network ASN are shown. For the truncated back pressure signals the number 21 (or 28) means that this is the back pressure signal for the logical queue number 1 (or 8) in the second statistical multiplex unit SMU.

In the switching elements SE shown in Fig. 2 there are no dedicated queues to separate the service classes variable bit rate (VBR) traffic and available bit rate (ABR) traffic within the class of non real time traffic. It is proposed to give VBR traffic time priority over the ABR traffic only in the queues of the upstream and the downstream

statistical multiplex units SMU. Therefore each logical queue in the statistical multiplex units SMU needs a third subqueue. For the ABR-traffic only a third threshold T_A with $T_A < T_N$ is required. Considering the case when the queue level is greater than T_A but lower than T_N and one queue is sending VBR-traffic and an other queue is sending ABR-traffic. The "ABR-queue" receives a back pressure signal after each transmission of a cell and is stopping the transmission for its time-out period. The "VBR-queue" receives no back pressure signal and transmits a cell in each cell cycle. There is no additional back pressure signal needed for ABR-traffic.

In the forgoing the present invention was described only as example in connection with an ATM communication system according to Fig. 2. But the present invention is not restricted to this embodiment. Rather it is generally useable in ATM communication systems comprising a plurality of upstream interfaces connected to at least one funnel of switching elements and at least one downstream interface connected to the last switching element of the respective funnel. The switching elements can be in each case of the structure m/n , whereby m denotes the number of inputs and n the number of outputs of a switching element.

Claims

1. ATM communication system for statistical multiplexing of message cells belonging to virtual connections of at least two different traffic classes according to an asynchronous transfer mode, said ATM communication system comprising a plurality of upstream interfaces in each case with an output to which at least one logical queue is associated, at least one multistage funnel of switching elements connected to said plurality of upstream interfaces and at least one downstream interface connected to the last switching element of the respective funnel, whereby each of the switching elements comprises a plurality of inputs and at least one output to which a logical queue is associated, **characterized**, that the logical queue of each of the switching elements is common for the different traffic classes, that for the filling of the logical queue of the respective switching element to each of the traffic classes a predetermined threshold is defined, that in case of exceeding the threshold for the respective traffic class by receiving a message cell for this traffic class a back pressure signal is transmitted by the respective switching element only to the switching element or upstream interface, respectively, just transmitting this message cell and that by the switching element or upstream interface, respectively, just receiving the back pressure signal the transmission of message cells is stopped for a predetermined period of time periodically until resetting the back pressure signal.
2. ATM communication system according to claim 1, **characterized**, that it comprises a plurality of funnels of switching elements connected on the input side in parallel to the plurality of upstream interfaces and on the output side in each case to a downstream interface, that the upstream interfaces comprises in each case a plurality of logical queues associated individually to one of the downstream interfaces and that in receiving a back pressure signal the transmission of message cells is only stopped by the respective upstream interface for the switching element transmitting this back pressure signal.
3. ATM communication system according to claim 1 or 2, **characterized**, that in each of the logical queues of the switching elements a first threshold for non real time traffic and a second threshold for real time traffic greater than the first threshold are defined.

FIG 1

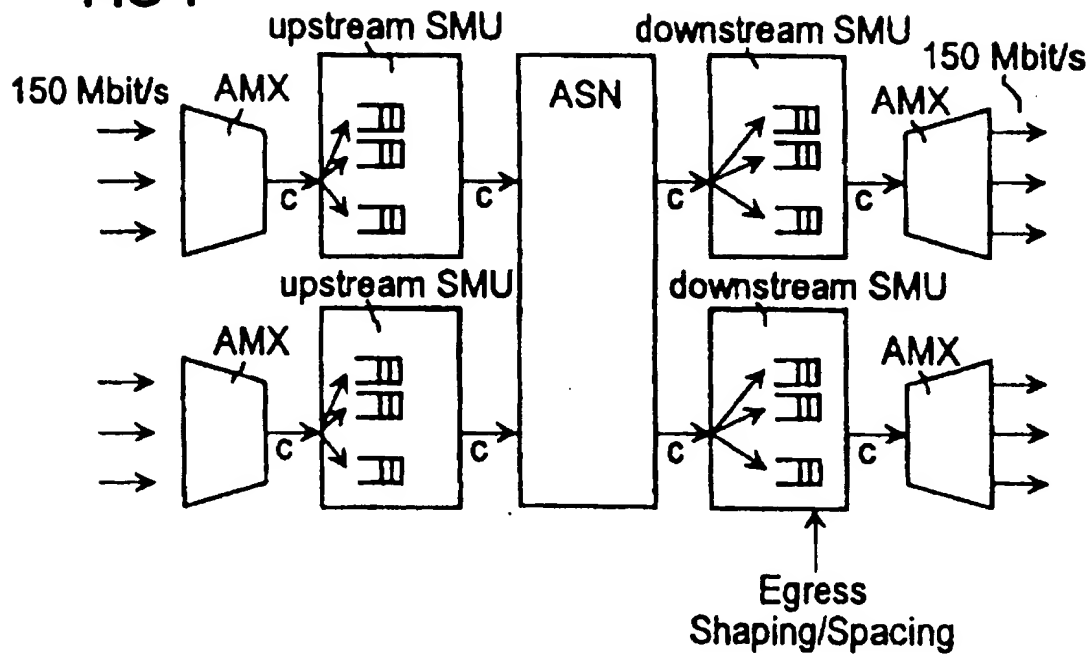


FIG 2

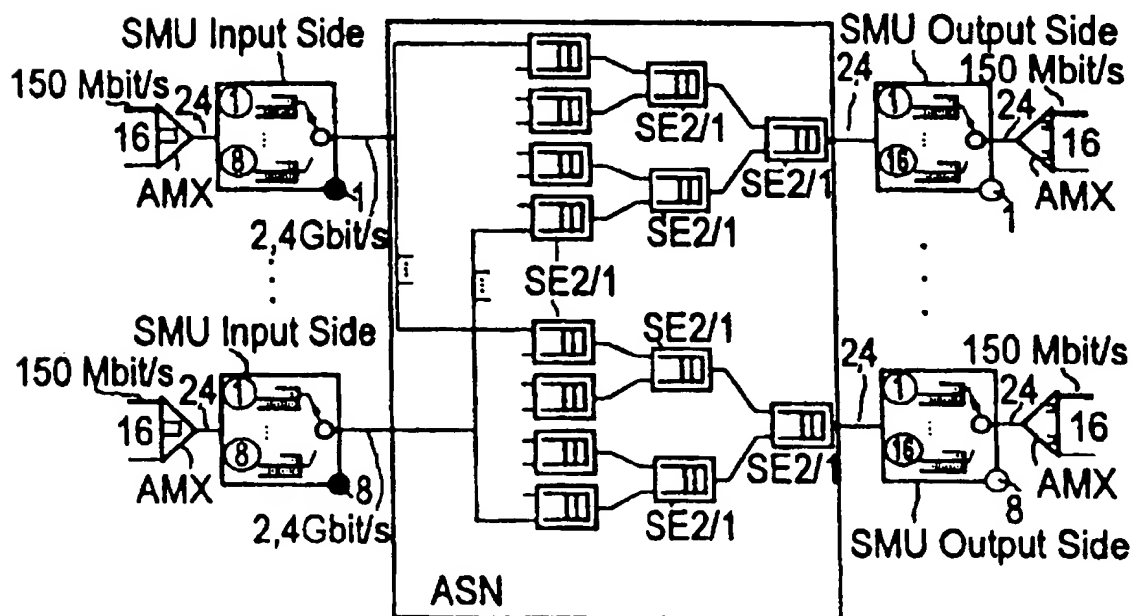


FIG 3

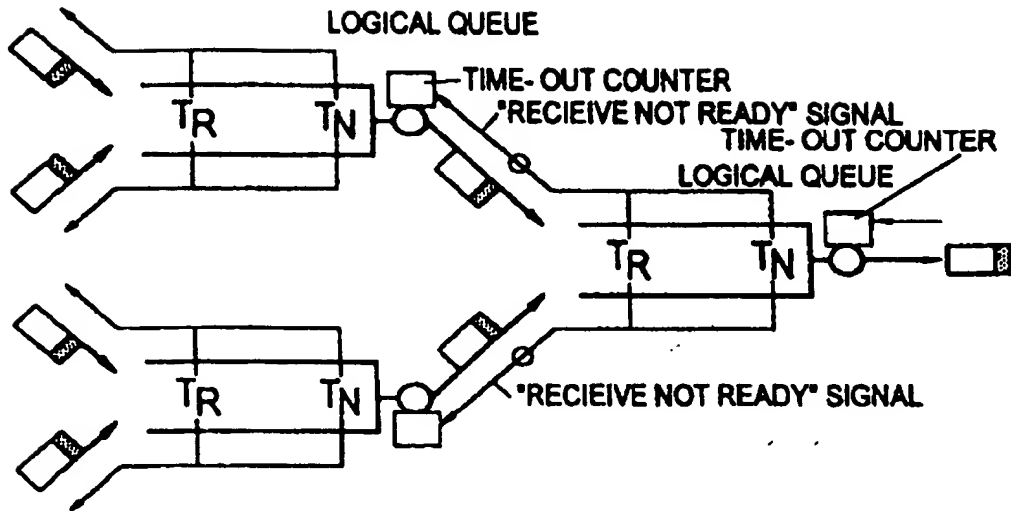
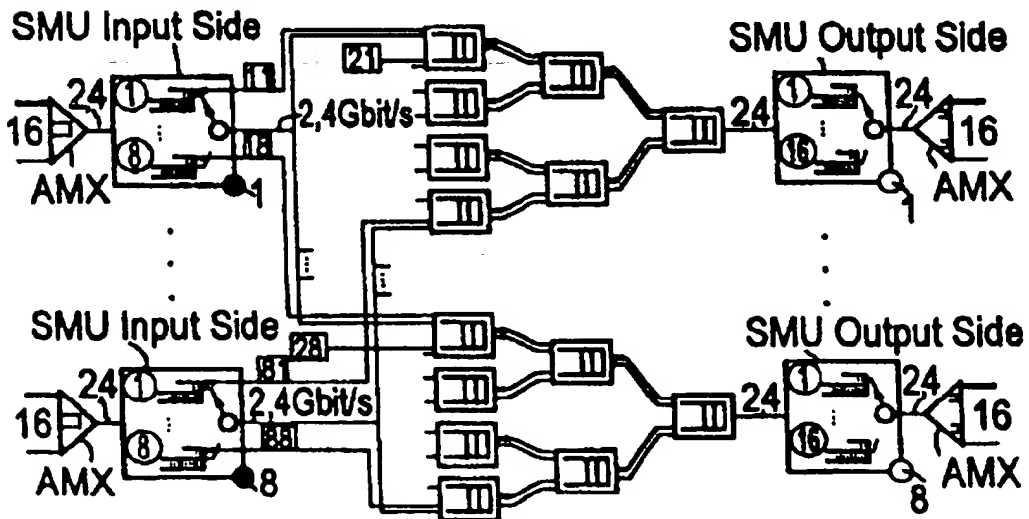


FIG 4





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EUROPEAN SEARCH REPORT

Application Number
EP 94 11 5289

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	EP-A-0 471 256 (HITACHI) * abstract; claims 1-13; figures 1-5 * ---	1-3	H04L12/56 H04Q11/04
Y	IEEE GLOBECOM 93, vol.3, 29 November 1993, HOUSTON, USA pages 1375 - 1383, XP436044 A. CHOUDHURY ET AL * Section 3 * ---	1-3	
A	IEEE GLOBECOM 93, vol.3, 29 November 1993, HOUSTON, USA pages 1476 - 1480, XP436061 W. FISCHER ET AL * Section 5 * -----	1,2	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H04L H04Q
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 14 March 1995	Examiner Ali, A
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